TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 181. OCTOBER, 1915.

DIVISION OF CHEMISTRY

Oxidation of Organic Compounds in the Soil

POSTOFFICE:
COLLEGE STATION, BRAZOS COUNTY, TEXAS

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BY

G. S. FRAPS, Ph. D.,
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*As of October 1, 1915.
**In Cooperation with the United States Department of Agriculture.

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OXIDATION OF ORGANIC MATTER IN THE SOIL

BY

G. S. FRAPS, CHEMIST IN CHARGE, STATE CHEMIST.

The oxidation of organic matter in the soil is a matter of considerable agricultural importance. Ammonia and nitrates are prepared for the use of plants, in such oxidation, and the carbon dioxide produced is also believed to aid in the solution of mineral plant food. The organic matter modifies the physical properties of the soil, and its destruction or loss from the soil may give rise to changes in physical character.

The oxidation of organic matter containing nitrogen could be studied indirectly by means of the nitrates and ammonia produced. We might assume that the oxidation of the carbon proceeds at the same rate as the oxidation of nitrogen. We would not, however, be justified in the assumption that the production of nitrates alone and the oxidation of organic carbon proceeds at the same rate, since ammonia is not immediately oxidized to nitrates. The direct study of the changes in organic matter or carbon in the soil is more satisfactory than any assumption.

A considerable amount of work upon the oxidation of organic matter in the soil has been done by Wollny, and is reported in his book upon the subject (Wollny—*Die Zersetzung der Organischen Stoffe*, 1896). Most of the experiments cited in Wollny's work were carried on with soils placed in glass tubes or similar vessels, through which a current of air was drawn to take out the carbon dioxide. Although such experiments are well adapted to estimate carbon dioxide, obviously, such conditions do not prevail in the soil, and while it is possible that Wollny's conclusions may apply to the soil under natural conditions, yet it is also possible that the oxidation may proceed somewhat differently in soils less well aerated. It is known, for example, that nitrification in a liquid culture is not the same as nitrification in the soil. Cottonseed meal will putrefy in soil in flasks stoppered with cotton wool, while in glass jars, the same mixture will nitrify. A soil in a glass tube through which a current of air is drawn will be better supplied with oxygen than a soil under natural conditions, and therefore organic matter may be oxidized differently in it.

Oxidation of organic matter in the soil will depend upon the nature of the organic material oxidized, and the ability of the soil to support the oxidizing organisms, in addition to other variable influences, such as the kind and relative numbers of bacteria, temperature, the water content, the quantity of oxygen in the soil, etc. Just as the relative ability of the soil to support nitrifying organism has been termed its *nitrifying capacity*, so the relative power of the soil to support oxidizing organisms may be termed its *oxidation capacity*. The nitrifying capacity, the oxidation capacity and the capacity of the soil to convert ammonia into nitrates and ammonia are to a certain extent related, espe-

cially the two latter. They are not necessarily the same in the same soils, however, and do not necessarily vary in the same way under the influence of different factors.

STUDY BY MEANS OF LOSS ON IGNITION.

The estimation of the loss on ignition of a soil is well known *not* to be a satisfactory indication of the organic matter contained in the soil. The quantity of organic matter is sure to be less than the amount of loss on ignition, but can not be greater than this amount. Soils always contain water of combination or hydration, which is not lost at 100° C. but is lost on ignition. A clay may thus have a high loss on ignition, but contain little organic matter.

If we work on the same soil, however, making various additions to it, the loss on ignition may be used as an approximate measure of the quantity of organic matter lost or gained. Such results are comparative, as different samples of the same soil may be assumed to contain the same quantities of water of hydration. The method can not be claimed to have a high degree of accuracy.

Results with the Method.—The loss on ignition was determined in a number of the mixtures of soil and organic matter prepared for the study of the loss or gain of ammonia-soluble organic matter of the soil. (See Bulletin 129.) In order to secure comparable results, the loss on ignition has been calculated to the percentages of the ignition residue of the soil or mixture. This is necessary, for the ignition residue should not vary, while the quantity of water and loss on ignition will vary with the quantity of organic residues present. The method of calculation is shown in Table 1.

TABLE 1—METHOD OF CALCULATION.

	Soil 895	Soil 914
Ignition residue		
In 100 gm. soil	97.46	97.89
In 4 gm. excrement	0.20	0.20
Total	97.66	98.09
Loss on ignition		
In 100 gm. soil	1.90	1.74
In 4 gm. excrement	3.53	3.53
Total	5.43	5.27
Loss on ignition calculated to 100 gm. ignition residues	5.56	5.37

Intervals of Time.—Several mixtures of soil with excrement were prepared, kept moist, and a jar of each soil mixture was dried for analysis at various periods of time. The results are presented in Table 2. The organic matter disappears rapidly during the first few weeks. After that time the loss on ignition is irregular, and it is difficult to follow the changes in the organic matter by this method. In this work, 20 grams excrement was mixed with 500 grams soil.

TABLE 2—LOSS ON IGNITION AT VARIOUS PERIODS, IN PERCENTAGE OF IGNITION RESIDUE.

	Soil 895	Soil 914	Soil 958
Original mixture	5.55	5.37	11.87
After 2 weeks	5.35	4.72	11.20
After 4 weeks	5.09	.....	11.41
After 5 weeks	5.16	4.64	11.48
After 7 weeks	4.74	4.47	10.79
After 9 weeks	4.26	4.23	10.72
After 11 weeks	4.76	3.97	10.69
After 13 weeks	4.94	4.43	10.68
After 15 weeks	5.03	4.52	11.21
After 19 weeks	4.80	4.04	10.81
After 21 weeks	4.89	4.42	11.23
After 23 weeks	4.97	4.65	10.64
After 25 weeks	4.31	4.12	10.15

Nature of Material.—Table 3 shows the loss on ignition of soils which received various additions, after standing while moist at room temperatures for 14 weeks and also the original dry mixture. In Table 4 the loss on ignition of the original soil is subtracted, showing losses due to the added material. The loss on ignition of the original mixtures is calculated as shown in Table 1, from the composition of the soil and of the organic substances used. Analyses of the soils are given in Table 22, and description on page 24.

TABLE 3—LOSS OF ORGANIC MATTER FROM VARIOUS MATERIALS MEASURED BY LOSS ON IGNITION IN PERCENTAGE OF IGNITION RESIDUES.

Added	Lufkin Fine Sand.		Orangeburg Fine Sandy Loam.		Orangeburg Fine Sand.	
	Soil 895		Soil 958		Soil 885	
	Original Mixture.	After 14 Weeks.	Original Mixture.	After 14 Weeks.	Original Mixture.	After 14 Weeks.
No addition	1.97	1.99	8.00	7.88	1.80	1.86
Blood	5.51	3.44	11.85	9.12	5.35	3.06
Excrement	5.56	4.80	11.90	10.79	5.38	4.89
Cottonseed Meal	5.54	2.91	11.87	8.40	5.34	2.81
Meat	4.01	3.06	10.45	8.69	4.76	2.98
Rice hulls	5.31	2.93	.....	.....	.....	.....
Bat guano	5.21	4.62	.....	.....	.....	.....
Tankage	4.35	2.83	.....	.....	.....	.....
Wheat bran	5.46	3.05	.....	.....	.....	.....
Corn chops	5.61	2.67	.....	.....	.....	.....
Wheat shorts	5.48	2.72	.....	.....	.....	.....

TABLE 4—LOSS ON IGNITION DUE TO ADDED ORGANIC MATERIAL.

	Lufkin Fine Sand.			Orangeburg Fine Sandy Loam.			Orangeburg Fine Sand.		
	Soil 895			Soil 958			Soil 885		
	Original.	After 14 Weeks.	Per cent Lost.	Original.	After 14 Weeks.	Per cent Lost.	Original.	After 14 Weeks.	Per cent Lost.
Blood	3.54	1.45	59	3.85	1.24	68	3.55	1.26	64
Excrement	3.59	2.81	22	3.90	2.91	25	3.58	3.03	15
Cottonseed meal	3.57	0.92	74	3.87	.52	87	3.54	.95	73
Meat	2.04	1.07	47	2.45	.81	67	2.96	1.12	62
Rice hulls	3.34	0.94	72	.....	.....	.....	.....	.....	.....
Bat guano	3.24	2.63	19	.....	.....	.....	.....	.....	.....
Tankage	2.38	0.84	65	.....	.....	.....	.....	.....	.....
Wheat bran	3.49	1.06	70	.....	.....	.....	.....	.....	.....
Corn chops	3.64	0.68	81	.....	.....	.....	.....	.....	.....
Wheat shorts	3.51	0.73	79	.....	.....	.....	.....	.....	.....

For the results of the experiments, see Tables 3 and 4. It would appear from this experiment that cottonseed meal, corn chops, rice hulls, and wheat shorts, are the most easily oxidized of the materials tested, from 72 to 81 per cent being oxidized in 14 weeks. Considering the woody nature of rice hulls, it is strange that it is so easily oxidized, and other experiments may not confirm this result. Meat, blood, and tankage are less easily oxidized than are the vegetable materials, 47 to 68 per cent being lost. Excrement, as could be expected, is oxidized slowly (15 to 22 per cent). Bat guano was also oxidized slowly.

The period of this experiment was from October 17 to January 31. The jars were in an unheated basement. Without doubt, the temperature of the basement did not fall as low as the outside temperature of the air. Cottonseed meal, which is largely used as a fertilizer in Texas, would thus be oxidized fairly rapidly even during cool weather.

Oxidation of all the materials was more energetic in soil 958, Orangeburg fine sandy loam. Soils 895, Lufkin fine sand, and 885, Orangeburg fine sand, are apparently equal.

STUDY OF OXIDATION BY MEANS OF THE CARBON DIOXIDE PRODUCED.

In these experiments, 500 grams soil was mixed with the organic material and water, and placed in a precipitation jar. The jar was placed in an air-tight vessel, purified air drawn through at various intervals, the carbon dioxide absorbed by soda lime, and weighed. The details of the method of procedure are as follows:

The apparatus consisted of a precipitation jar placed inside of a Witt's filtering jar, absorption trains leading to and over from the filtering jar and an aspirator to draw a current of air through it. The funnel of the filtering flask was removed and a tightly fitting one-hole rubber stopper was paraffined into the opening in the cover. One end of a glass tube, bent at a right angle, was run through the hole in the stopper down to within a quarter of an inch of the surface of the soil, which is placed in the precipitating jar. To the other end of this tube is connected a train consisting of a spiral filled with sulphuric acid, a U tube filled with soda-lime, a U tube filled wth pumice stone and sulphuric acid, this train being used to purify the air drawn into the jar.

Into the side tube of the Witt jar was fitted the short end of a piece of glass tubing, bent to a right angle, and the joint made air-tight with sealing wax. The long end of the tube passed close to the side at the bottom of the filtering jar, in order to prevent carbon dioxide from collecting and remaining in the bottom of the jar. To the side tube of the filtering jar was connected an absorption train consisting of a sulphuric acid spiral, a U tube filled with pumice stone and sulphuric acid, two U tubes filled with soda-lime and a U tube filled with pumice stone and sulphuric acid, to absorb any water given up by the soda-lime tubes, and U tube filled one side with soda-lime and the other with calcium chloride to prevent any carbon dioxide or water from working backward. Then followed the aspirator. After the air

had been drawn through the apparatus, the tubes were carefully wiped, allowed to stand for a few minutes, and weighed—a U tube which had been similarly wiped and handled being used as a counterpoise. The jars when not connected with the train were kept tightly closed.

The conditions of our work are thus more nearly like natural soil conditions than those of Wollny. No air was drawn through the soil. There is, of course, risk of accumulation of carbon dioxide within the pores of the soil. Experiments described later showed, however, that any carbon dioxide held in this way would not affect the conclusions.

Soil conditions are, however, more favorable to oxidation in these experiments than in the natural soil, as pointed out in connection with the nitrification studies. (Texas Bulletin 106.)

COMPARISON OF VARIOUS MATERIALS.

First Series.—In this series of experiments, 2.5 grams material and water equal to one-third the saturation capacity of the soil was mixed with 500 grams soil. The soil used, No. 1133, is Norfolk fine sand, from Franklin county, and contains .02 per cent. nitrogen and produces one-fourth bale cotton or 15 bushels corn. For analysis see Table 22.

TABLE 5—GRAMS CARBON DIOXIDE FORMED IN THE SOIL.

	Cotton-seed Meal.	No Addi-tion.	Manure.	Wheat Bran.	Corn Chops.	Corn Cobs.
Carbon dioxide at the end of period (total 24 hours)	.4519	.0131	.1248	.....	.....	.....
Carbon dioxide at the end of period (total 48 hours)	.....	.0168	.....	.4879	.3082	.2220
Carbon dioxide at the end of period (total 72 hours)	.3589	.....	.3802	.5203	.4156	.....
Carbon dioxide at the end of period (total 96 hours)	.4546	.0149	.1901	.....	.....	.2193
Carbon dioxide at the end of period (total 120 hours)	.....	.....	.....	.5066	.4655	.....
Total formed (4 or 5 days)...	1.2654	.0448	0.6951	1.4148	1.1893	0.4413

The results of this experiment are given in Table 5. This experiment was conducted during the month of March.

Oxidation of the organic material begins very rapidly. Within the first 24 hours, nearly 0.5 grams carbon dioxide was formed from cottonseed meal. Since this meal contained approximately 1.15 grams carbon, equivalent to 5.2 grams carbon dioxide, this amount represents about ten per cent. of the carbon of the meal. Nearly 30 per cent. was oxidized in four days. The wheat bran is oxidized even more rapidly than the cottonseed meal. The order of oxidization in this experiment is as follows: Bran (first), cottonseed meal, corn chops, manure, cobs.

Second Series.—The object of this series was to compare the oxidation of cottonseed meal, manure, and corn cobs for a longer period of time than in the preceding experiments.

Five hundred grams of soil No. 1135 and 2.5 grams organic material were mixed with 50 c.c. water, placed in precipitation jars, and the jar placed in the apparatus for the collection of carbon dioxide. Every day the accumulated carbon dioxide was washed into the absorption apparatus by drawing two liters of air through the apparatus.

The soil used is Norfolk fine sandy loam of Franklin county, and contains .035 per cent. nitrogen, 12 parts per million of active phosphoric acid, 216 parts per million of active potash, and produces one-half bale cotton or 20 bushels of corn. (For analysis, see Table 22.)

TABLE 6—PRODUCTION OF CARBON DIOXIDE (IN GRAMS).

	Days.	No Addition.	Cotton-seed Meal.	Manure.	Corn Cobs.
April 22 (24 hours)	1	.0298	.1673	.0673	.0453
April 23	2	.0096	.3258	.0779	.0754
April 24	3	.0034	.2385	.0696	.0257
April 25	4	.0253	.2438	.0419	.0859
April 26	5	.0147	.3137	.0771	.1070
April 27	6	.0059	.2595	.0467	.0553
April 28	7	.0062	.1919	.0359	.0810
April 29	8	.0108	.1662	.0308	.0684
April 30	9	.0049	.0796	.0244	.0423
May 1	10	.0043	.0600	.0186	.0311
May 2	11	.0039	.0500	.0208	.0340
May 3	12	.0077	.0597	.0202	.0289
May 4	13	.0048	.0823	.0243	.0355
May 5	14	.0074	.0696	.0231	.0384
May 6	15	.0116	.0567	.0195	.0422

The results of the experiment are presented in table 6. Variations in the quantity of carbon dioxide produced from day to day are marked. These are, to some extent, related to changes in temperatures, for the apparatus was in all cases kept at room temperature. Oxidation begins rapidly and nearly reaches the maximum in forty-eight hours, though there is a second maximum at the end of four days. Thirty-eight and eight-tenths per cent. (38.8%) of the carbon of cottonseed meal, 10.1 of the manure, and 8.8 of the corn cobs, was oxidized the first week. Fifty-two and six-tenths per cent. (52.6%) of the carbon of the cottonseed meal, 14.1 of the manure, and 15.0 of the corn cobs, were oxidized during the two weeks.

At the end of fifteen days, nitrates and ammonia were estimated in all the jars, the nitrates by the Tiemann-Schulze method, and the ammonia by distillation with magnesium oxide, as described in Bulletin No. 106 of this Station. (See Table 7.)

TABLE 7—PRODUCTION OF NITRIC AND AMMONIA NITROGEN AND CARBON DIOXIDE.

	No Addition.	Cotton-seed Meal.	Manure.	Corn Cobs.
Milligrams nitric nitrogen	6.3	74.0	11.0	14.0
Milligrams ammonia nitrogen	1.6	37.1	7.8	2.2
Total	7.9	114.1	18.8	16.2
Percentage of carbon oxidized, first week	.....	38.8	10.1	8.8
Percentage of carbon oxidized, second week	.....	13.8	4.0	6.2
Total	.....	52.6	14.1	15.0
Percentage nitrogen oxidized to nitrates	.....	37.6	8.3	.....
Percentage nitrogen oxidized to ammonia	.....	19.7	10.9	.....
Total	.....	57.3	19.2	100 (?)

The oxidation which took place during this experiment was very vigorous. Nearly 40 per cent. of the cottonseed meal was oxidized the first week. It is known that the nitrogen of cottonseed meal must be changed to ammonia and nitrates before plants can take it up. This change takes place rapidly, and if the meal is placed in the ground at the time of planting, some ammonia and nitrates are formed, ready for the young plant, by the time the seed sprouts and begins to come up.

The oxidation of the nitrogen of both the cottonseed meal and the manure takes place at a somewhat greater rate than the production of carbon dioxide. The protein must be more easily oxidized than the non-protein materials, or else the protein is only partly oxidized, carbonaceous portions remaining after the nitrogen has been converted into ammonia and nitrates.

Third Series.—The object of this series was to compare the carbon dioxide produced from cottonseed meal, dung and humic acid during long periods of time. As in the preceding experiment, five hundred grams of soil (No. 1290) were mixed with 2.5 grams organic material and 50 c.c. water. Eight jars of each mixture were prepared. In each jar a test tube with a hole in the bottom was inserted to the depth of an inch. One jar of each material was placed in the carbon dioxide apparatus. The others were placed in an unused room, in a dark cupboard. At the end of each week, water was added through the test tube to replace that lost on evaporation. The jar in the carbon dioxide apparatus was taken out, the apparatus ventilated, and a new jar of soil placed therein. Nitrates and ammonia were estimated in the soil taken out in the old jar. A fresh portion of soil was thus used in the experiment every week. Soil No. 1290, used in this work, is Norfolk sand from Anderson county, and contains 0.02 per cent. nitrogen. (See table 12 for analysis.) The humic acid was prepared by solution in ammonia, from a soil from South Dakota. The excrement consisted of solid and liquid excrement, sun dried.

Carbon dioxide was estimated every day for the first thirteen days; after that time, on alternate days only. This was done on account of the decreased rate of evolution of carbon dioxide.

TABLE 8—CARBON DIOXIDE IN GRAMS PRODUCED FROM SOIL AND MIXTURE.

Date.		Cotton-seed Meal.	Dung.	Humic Acid.	Nothing
May 12	End of first 24 hours	.2460	.0561	.0203	.0267
May 13	End of second 24 hours	.3166	.0730	.0166	.0355
May 14	End of third 24 hours	.2756	.0778	.0162	.0300
May 15	End of fourth 24 hours	.2141	.0903	.0161	.0154
May 16	End of fifth 24 hours	.1954	.1205	.0153	.0128
May 17	End of sixth 24 hours	.1750	.0908	.0090	.0088
May 18	End of seventh 24 hours	.1309	.0744	.0050	.0030
	Total, first week	.5536	.5829	.0985	.1322
May 19	End of first 24 hours	.0270	.0361	.0102	.0080
May 20	End of second 24 hours	.0896	.0726	.0115	.0112
May 21	End of third 24 hours	.1072	.0803	.0138	.0017
May 22	End of fourth 24 hours	.0985	.0621	.0114	.0057
May 23	End of fifth 24 hours	.0984	.0530	.0212	.0112
May 24	End of sixth 24 hours	.....	.....	.....	.....
May 25	End of seventh 24 hours	.1008	.0628	.0255	.0117
	Total, second week	.5215	.3669	.0936	.0495
May 27		.0714	.0535	.0267	.0220
May 29		.0616	.0594	.0249	.0225
May 30		.0438	.0376	.0206	.0188
June 1		.0486	.0497	.0290	.0229
	Total, third week	.2254	.2002	.1012	.0862
June 3		.0443	.0514	.0271	.0208
June 5		.0416	.0594	.0275	.0207
June 6		.0331	.0388	.0202	.0167
June 8		.0286	.0489	.0218	.0155
	Total, fourth week	.1476	.1985	.0966	.0737
June 10		.0329	.0336	.0297	.0344
June 12		.0292	.0270	.0248	.0188
June 13		.0209	.0300	.0175	.0131
June 15		.0267	.0268	.0148	.0179
	Total, fifth week	.1097	.1174	.0868	.0842
June 17		.0275	.0340	.0143	.0129
June 19		.0305	.0224	.0267	.0160
June 21		.0215	.0145	.0148	.0139
June 22		.0169	.0138	.0185	.0131
	Total, sixth week	.0964	.0844	.0743	.0559

TABLE 9—WEEKLY PRODUCTION OF CARBON DIOXIDE.

	Cotton-seed Meal.	Dung.	Humic Acid.	No Addi-tion.
Carbon dioxide first week	1.5536	.5829	.0985	.1322
Carbon dioxide second week	0.5215	.3669	.0936	.0495
Carbon dioxide third week	0.2254	.2002	.1012	.0862
Carbon dioxide fourth week	.1476	.1985	.0966	.0737
Carbon dioxide fifth week	.1097	.1174	.0868	.0842
Carbon dioxide sixth week	.0464	.0844	.0743	.0559
Total	2.6042	1.5503	.5510	.4817

The details of the experiment are presented in Table 8. Weekly production of carbon dioxide is shown in Table 9. The production decreases rapidly from the first week, especially with cottonseed meal. With humic acid, there is a more uniform evolution of carbon dioxide. With the soil alone, a decrease of production of carbon dioxide takes place in the second week.

When organic matter is mixed intimately with the soil, and during moderately warm weather, as during this experiment, the oxidation of such materials as cottonseed meal is very rapid. The bacteria of the soil lose little time in going into action to dispose of the organic material introduced. The oxidation is most rapid during the first week, and decreases during succeeding weeks. The quantity of carbon dioxide formed from the cottonseed meal in the two weeks is about 10 per cent. less than in the preceding experiment.

The humic acid apparently decreased oxidation during the first week. Whether the slight deficiency in carbon dioxide over the soil with no addition is due to an error on the experiment, or the nature of the humic acid, we will not undertake to say.

The amount of carbon dioxide which would be produced from the carbon of the organic materials used in this experiment, if completely converted into carbon dioxide, is given in Table 10, together with the amount of carbon dioxide actually produced each week. By subtraction from the original amount, the quantity remaining at the end of each week is ascertained. From these figures, the percentage of carbon oxidized each week has ben calculated, based on the total quantity of added carbon present at the beginning of such week.

TABLE 10—PERCENTAGE OF CARBON DIOXIDE FROM THE MATERIAL PRESENT AT THE BEGINNING OF EACH WEEK.

	Cottonseed Meal.	Dung.	Humic Acid.
Substance equal to carbon dioxide added	4.21	3.67	3.57
Lost end first week	1.42	.45	—.03
Balance at end of first week	2.79	3.22	3.60
Per cent loss	33.7	12.3	0
Lost second week	.47	.32	.04
Balance at end second week	2.32	2.90	3.56
Per cent loss	16.8	10.0	1.1
Lost third week	.14	.11	.02
Balance third week	2.18	2.79	3.54
Per cent loss	6.0	4.0	0.6
Lost fourth week	.06	.12	.02
Balance fourth week	2.12	2.67	3.56
Per cent loss	3.	4.	0.6
Lost fifth week	.03	.03	.003
Balance at end fifth week	2.09	2.64	3.567
Per cent loss	1.	1.	.....
Lost sixth week	.04	.03	.02
Balance at end of sixth week	2.05	2.61	3.55
Per cent loss	2.	1.	0.5

This table emphasizes the fact that the oxidation decreases rapidly after the first week. With cottonseed meal, the oxidation of each week after the first is approximately one-half as much of that of the preceding week, until the oxidation becomes so slow as to be hardly distinguishable from that of the soil material. The decrease in the oxidation of the dung is less rapid, but still marked. Humic acid, as

could be expected, is very resistant towards the oxidation processes. Its oxidation during the first week is a minus quantity, and during the second week its oxidation is about one-tenth that of the dung. Nearly the same relation holds during the third and fourth week.

During the fourth and fifth weeks, the oxidation is very slight, and hardly distinguishable from that of the organic matter of the soil. That is to say, in four weeks, the added organic material was oxidized down to very resistant organic bodies.

Had this experiment been carried on under less favorable conditions, such as at a lower temperature, the oxidation would probably not have been so rapid at first, and it would have fallen off less rapidly. A longer time might also have been required to oxidize the material down to resistant substances similar to those in the soil.

EFFECT OF NATURE OF SOIL.

The object of this work was to ascertain what effect, if any, the nature of the soil had upon the production of carbon dioxide. The experiments were carried out as previously described; namely, with 500 grams soil, 2.5 grams excrement, and water to one-third the saturation capacity of the soil. For purposes of comparison, a standard soil was chosen, which was placed in all series of experiments. Each soil was run both with and without the addition of excrement.

The first experiment was only continued for six days. We found later that all soils did not begin to oxidize at the same rate, and those behind at the end of the first six days might begin to catch up during the second period. For this reason, the succeeding series of experiments were carried on for longer periods of time. In all these series of experiments, carbon dioxide was determined every day. We do not consider it necessary, however, to print all the figures secured.

Summaries of the various series are given in Tables 11, 12, 13 and 14. Table 22 shows the composition of the soils used.

TABLE 11—OXIDATION OF EXCREMENT IN VARIOUS SOILS.

Soil No.		Grams Per Pot.			Relative Rank.		
		First three Days.	Second three Days.	Total for six Days.	First three Days.	Second three Days.	Total for six Days.
	Set No. 1.						
1956	With excrement	.1323	.1563	0.2886	100	100	100
	No addition	.0455	.0270	.0725	100	100	100
	CO_2 from excrement	.0868	.1293	0.2161	100	100	100
880	With excrement	.0670	.1590	.2260	.....	.....	.....
	No addition	.0161	.0430	.0591	35	159	81
	CO_2 from excrement	.0509	.1160	.1669	59	90	77
1128	With excrement	.0322	.0391	.0713	.....	.....	.....
	No addition	.0223	.0142	.0385	49	53	53
	CO_2 from excrement	.0099	.0249	.0348	11	19	16
897	With excrement	.1499	.1399	.2898	.....	.....	.....
	No addition	.0982	.0605	.1587	216	224	219
	CO_2 from excrement	.0517	.0794	.1311	60	61	61
	Set No. 2.						
1956	With excrement	.1144	.2069	.3213	100	100	100
	No addition	.0520	.0220	.0740	100	100	100
	CO_2 from excrement	.0624	.1849	.2573	100	100	100

TABLE 11—OXIDATION OF EXCREMENTS IN VARIOUS SOILS—Continued.

Soil No.		Grams Per Pot.			Relative Rank.		
		First three Days.	Second three Days.	Total for six Days.	First three Days.	Second three Days.	Total for six Days.
876	With excrement	.0307	.0212	.0519			
	No addition	.0137	.0083	.0220	26	38	30
	CO_2 from excrement	.0125	.0129	.0254	20	7	10
938	With excrement	.1225	.2424	.3649			
	No addition	.0758	.0660	.1418	146	300	192
	CO_2 from excrement	.0467	.1764	.2231	75	95	87
1119	With excrement	.1132	.1950	.3082			
	No addition	.0792	.0263	.1055	152	119	143
	CO_2 from excrement	.0340	.1687	.2027	55	91	79

TABLE 12—PRODUCTION OF CARBON DIOXIDE IN SOILS.

Soil No.		Grams Per Pot.					Relative Rank.				
		First three Days.	Second three Days.	Third three Days.	Fourth three Days.	Total.	First three Days.	Second three Days.	Third three Days.	Fourth three Days.	Total.
1956	With excrement	.1165	.1392	.0605	.0886	.4048					
	No addition	.0274	.0197	.0157	.0151	.0786	100	100	100	100	100
	Difference	.0891	.1195	.0448	.0728	.3262	100	100	100	100	100
1809	With excrement	.1143	.2283	.0933	.0873	.5232					
	No addition	.0608	.0468	.0222	.0232	.1530	222	238	141	153	194
	Difference	.0538	.1815	.0711	.0641	.3702	60	152	149	88	114
870	With excrement	.0798	.1747	.1089	.0645	.4279					
	No addition	.0284	.0266	.0258	.0149	.0957	104	135	164	99	122
	Difference	.0514	.1481	.0831	.0496	.3322	58	124	185	68	102

Table 15 shows the relative production of carbon dioxide from the excrement added to the various soils, compared with soil No. 1956 as a standard. These soils are arranged in the table in order according to their content of total nitrogen, beginning with the soil containing the least nitrogen. There are considerable differences in the first three days, which tend to equalize during the next succeeding three days so that the differences are less at the end of six days. The differences equalize still more during the succeeding six days, and for the period of twelve days, or of eighteen days, there is comparativley little difference in the power of the different soils for producing carbon dioxide from the excrement, with three exceptions, soils Nos. 341, 1128, and 876.

TABLE 13—PRODUCTION OF CARBON DIOXIDE IN SOILS.

Soil No.		Grams Per Jar.			Relative Rank.	
		First six Days.	Second six Days.	Total twelve Days.	First six Days.	Twelve Days.
1956	With excrement	.3506	.2525			
	No addition	.0582	.0344	.0926	100	100
	Difference	.2924	.2181	.5105	100	100
341	With excrement	.1022	.2157			
	No addition	.0460	.0660	.1120	79	121
	Difference	.0562	.1497	.2059	19	40
857	With excrement	.2201	.2998			
	No addition	.0508	.0318	.0826	87	89
	Difference	.1693	.2680	.4373	58	86
1075	With excrement	.3345	.3856			
	No addition	.1407	.1086	.2493	241	269
	Difference	.1938	.2750	.4688	66	92
1202	With excrement	.3055	.3356			
	No addition	.0690	.0893	.1583	118	171
	Difference	.2365	.2463	.4828	81	95
1956	With excrement	.3766	.2209			
	No addition	.0616	.0414	.1030	100	100
	Difference	.3150	.1795	.4945	100	100
114	With excrement	.2588	.3700			
	No addition	.0754	.0869	.1623	122	157
	Difference	.1834	.2831	.4665	58	94
336	With excrement	.4333	.3595			
	No addition	.1833	.0821	.2654	297	257
	Difference	.2500	.2774	.5274	79	107
939	With excrement	.2919	.4033			
	No addition	.1466	.1089	.2555	238	248
	Difference	.1453	.2944	.4397	46	89
1067	With excrement	.2891	.3368			
	No addition	.0792	.0772	.1564	129	152
	Difference	.2092	.2596	.4688	66	95

TABLE 14—PRODUCTION OF CARBON DIOXIDE IN SOILS.

Soil No.		Grams Per Pot.					Relative Rank.		
		First six Days.	Second six Days.	Total twelve Days.	Third six Days.	Total eighteen Days.	First six Days.	Twelve Days.	Eighteen Days.
1956	With excrement	.4801	.2592		.2040				
	No addition	.0907	.0594	.1501	.0494	.1995	100	100	100
	Difference	.3894	.1998	.5892	.1546	.7438	100	100	100
341	With excrement	.1904	.2950		.1620				
	No addition	.1029	.0760	.1789	.0527	.2316	113	119	116
	Difference	.0875	.0527	.1402	.1093	.2495	22	24	34

TABLE 14—PRODUCTION OF CARBON DIOXIDE IN SOILS—Continued.

Soil No.		Grams Per Pot.					Relative Rank.		
		First six Days.	Second six Days.	Total twelve Days.	Third six Days.	Total eighteen Days.	First six Days.	Twelve Days.	Eighteen Days.
876	With excrement	.1773	.3254	.....	.1868	.....	.....	.....	.....
	No addition	.0283	.0337	.0620	.0328	.0948	31	41	48
	Difference	.1490	.2917	.4407	.1540	.5947	38	48	80
897	With excrement	.5776	.3068	.....	.1697	.....	.....	.....	.....
	No addition	.1719	.0833	.2552	.0761	.3313	189	170	166
	Difference	.4057	.2235	.6292	.0936	.7228	104	107	97
1128	With excrement	.1531	.2652	.....	.1646	.....	.....	.....	.....
	No addition	.0737	.0527	.1264	.0373	.1637	81	84	82
	Difference	.0794	.2125	.2919	.1273	.4192	20	50	56

TABLE 15—RELATIVE PRODUCTION FROM EXCREMENT.

Lab. No.		3 Days.	6 Days.	12 Days.	18 Days.	Per cent. Nitrogen
897	Norfolk fine sand, surface soil	.....	104	107	97	.028
897	Norfolk fine sand, surface soil	60	61	.....	.....	.028
880	Austin fine sandy loam, subsoil	59	77	.....	.....	.028
1956	Sand, Brazos county, surface soil	100	100	100	100	.033
341	Susquehanna fine sandy loam, subsoil	.....	22	24	34	.04
341	Susquehanna fine sandy loam, subsoil	.....	19	40	.....	.....
1119	Susquehanna fine sand, surface	55	79	.....	.....	.058
857	Orangeburg fine sandy loam, subsoil	.....	58	86	.....	.050
1067	Susquehanna fine sandy loam, subsoil	.....	66	95	.....	.058
870	Laredo fine sandy loam, subsoil	58	102	.....	.....	.061
1202	Victoria clay, surface	.....	81	95	.....	.066
938	Austin fine sandy loam, surface	75	87	.....	.....	.089
336	Susquehanna fine sandy loam, surface	.....	79	107	.....	.099
1128	Houston clay, subsoil	.....	20	50	56	.10
1128	Houston clay subsoil	49	53	.....	.....	.10
876	Wilson clay loam, subsoil	.....	38	48	80	.10
876	Wilson clay loam, subsoil	20	10	.....	.....	.10
1809	Surface soil, Brazos county	60	114	.....	.....	.108
939	.....	.....	46	89	.....	.13
114	Travis gravelly loam, surface	.....	58	94	.....	.13
1075	Laredo clay, subsoil	.....	66	92	.....	.195

In Bulletin No. 106, we pointed out the fact (from a study of five soils only) that, while the nitrifying capacity of different soils may vary widely, the power of the soil for activating nitrogen, exhibits much less differences. While the five soils varied from 100 to 5 in nitrifying capacity, the variation in nitrogen activating capacity would varied only from 100 to 70. We apply the term nitrifying capacity to the ability of a soil to serve as a medium for the growth of the nitrifying organism compared with some other soil of good nitrifying capacity taken as a standard. The two soils are provided with nitrifying materials and placed under conditions which are alike in other respects. Cottonseed meal was used as the source of nitrogen in this work. We apply the term of nitrogen activating capacity to the power of the soil to produce ammonia and nitrate from a nitrifying substance compared with a soil of good nitrogen activating capacity under the

same conditions. We will also apply the term oxidation capacity to the ability of the soil to produce carbon dioxide from the excrement as used in the experiments compared with the standard soil.

There is thus a great variation in the nitrifying capacity of the soil, a much smaller variation in the nitrogen activating capacity of soils, and a still less variation in the oxidation capacity. There are, however, some exceptions to this rule. Three of the seventeen soils were decidedly lower in oxidation capacity. These soils were Nos. 341, 1128 and 876. Soil No. 341 is the subsoil of Susquehanna fine sandy loam, soil No. 1128 is the subsoil to Houston clay, and soil 876 is the subsoil to Wilson clay loam. All three of these soils, therefore, are subsoils of clay nature, which may account in part for their low oxidation capacity. Soil No. 876 shows a tendency to approach the normal oxidation capacity at the end of eighteen days, but soils Nos. 1128 and 341 are still low in this respect. Soil No. 1128 was used in some nitrification work and showed practically no power whatever to convert nitrogen into nitrate. The addition of carbonate of lime, however, gave it a good nitrifying capacity. The low nitrifying capacity in this case is associated with the low oxidizing power. It will be interesting to ascertain whether this is the case with other soils which show a low nitrifying capacity.

OXIDATION OF SOIL CARBON.

Table 16 shows the relative oxidation of the soil carbon compared with soil No. 1956 as a standard. The soils are arranged in order of their nitrogen content, beginning with the ones containing the least nitrogen. This is also the probable order of their carbon content. The three-day period and six-day period are too short to secure comparative results. The twelve-day period is better. There are decided differences in the relative quantities of carbon dioxide produced from the soil carbon.

TABLE 16—RELATIVE PRODUCTION FROM SOIL CARBON.

Lab. No.		3 Days.	5 Days.	12 Days.	18 Days.	Per cent. Nitrogen	Ratio $N:CO_2$
897	Norfolk fine sand, surface soil	.....	189	170	166	.028	190
897	Norfolk fine sand, surface soil	216	219	.....	.....	.028	.....
880	Austin fine sandy loam, subsoil	35	81	.....	.....	.028	.....
1956	Sand, Brazos county, surface soil	100	100	100	100	.033	100
341	Susquehanna fine sandy loam subsoil	.....	113	119	116	.....	100
341	Susquehanna fine sandy loam subsoil	.....	79	121	.....	.04	100
1119	Susquehanna fine sand, surface	152	143	.....	.....	.058	.....
857	Orangeburg fine sandy loam, subsoil	.....	87	89	.....	.050	60
1067	Susquehanna fine sandy loam, subsoil	.....	129	152	.....	.058	85
870	Laredo fine sandy loam, subsoil	104	.....	122	.....	.061	68
1202	Victoria clay, surface	.....	118	171	.....	.066	86
938	Austin fine sandy loam, surface	146	192	.....	.....	.089	.....
336	Susquehanna fine sandy loam, surface	.....	297	257	.....	.099	86
1128	Houston clay, subsoil	49	53	.....	.....	.10	.....
1128	Houston clay, subsoil	.....	81	84	82	.10	28
876	Wilson clay loam, subsoil	26	30	.....	.....	.10	.....
876	Wilson clay loam, subsoil	.....	31	41	48	.10	14
1809	Surface soil, Brazos Co.	222	.....	194	.....	.108	60
939	.....	.....	238	248	.....	.13	63
114	Travis gravelly loam, surface	.....	122	157	.....	.13	40
1075	Laredo clay, subsoil	.....	241	269	.....	.195	48

The differences in the production of carbon dioxide from the soil carbon are due partly to the oxidation capacity of the soil and partly to the quantity and to the character of the organic material contained in the soil. For the purposes of further comparison, we have reduced the carbon dioxide produced in twelve days to terms of a soil containing .033 per cent. nitrogen (No. 1956). This is given in the column headed "Ratio of nitrogen to carbon dioxide." An examination of this table shows that the organic matter of some of these soils must be in a more resistant form than in others. There are still decided differences, the quantity of carbon dioxide produced ranging from 14 to 190. Since we have previously pointed out that the oxidation capacity of these soils for excrement is nearly the same (except Nos. 341, 1128, and 876), these differences must be due largely to the nature of the soil carbonaceous compounds. The soil carbon seems to more easily oxidized from the soils containing the smaller nitrogen percentages. Thus the average ratio $N:CO_2$ for the three soils containing less than .04 per cent. nitrogen is 130, for the six soils containing .05 to .099 per cent. nitrogen is 81, and for the six soils containing over 0.1 per cent. nitrogen is 42. The number of samples is, of course, small to draw general conclusions, but the fact appears interesting.

The table brings out clearly the fact that there are greater differences in the capacity of the organic matter of the soil to be oxidized, than in the power of the soil to support the oxidizing organisms.

EFFECT OF QUANTITY OF WATER.

The object of this experiment was to determine the effect of the quantity of water present in the soil upon the production of carbon dioxide. As in previous experiments, 500 grams soil was used, with no addition except water, and with addition of excrement. Carbon dioxide was estimated every day.

The water was added in two different ways. In one series of experiments, the soil was placed in a porcelain dish, the water added, and the two mixed thoroughly by means of a spatula. The moist soil was then transferred to the precipitating jar, and placed in the carbon dioxide apparatus. (Table 17.)

TABLE 17—EFFECT OF QUANTITY OF WATER MIXED WITH SOIL ON CARBON DIOXIDE FORMED.

	1956					2378				
	5 c.c.	20 c.c.	65 c.c.	95 c.c.	125 c.c.	10 c.c.	25 c.c.	70 c.c.	100 c.c.	130 c.c.
First day	.0192	.0832	.0236	.0294	.0112	.0435	.0166	.0287	.0077	.0160
Second day	.1318	.1187	.1101	.0118	.0117	.1320	.0959	.0572	.0087	.0095
Third day	0.1310	.1278	.1857	.0333	.0116	.1299	.0745	.0791	.0077	.0048
Fourth day	0.1276	.0820	.1185	.0633	.0114	.0963	.1248	.0520	.0165	.0101
Fifth day	.1122	.1427	.0500	.1094	.0118	.0816	.0847	.0802	.0139	.0407
Sixth day	.0907	.0971	.1240	.0602	.0115	.0842	.0499	.0942	.0122	.0089
Seventh day	.0842	.0773	.0872	.0337	.0149	.0658	.0663	.0588	.0254	.0232
Totals	.6967	.7288	.6991	.3411	.0839	.6333	.5127	.4502	.0921	.1132
Saturated with water	1–25	1–6	1–2	3–4	Full	1–13	1–5	7–13	3–4	Full
Carbon dioxide formed in per cent of maximum	96	100	96	47	12	100	81	71	15	18

In the other series of experiments. the water was simply poured on to the surface of the soil, and allowed to soak in. (Table 18.) Soil No. 1956 is a sandy soil from Brazos county, containing .033 per cent. nitrogen. Soil No. 2378 is a red sandy soil from Cherokee county, and contains .043 per cent. nitrogen.

TABLE 18—EFFECT OF QUANTITY OF WATER ADDED ON TOP OF SOIL TO QUANTITY OF CARBON DIOXIDE FORMED.

	1956					2378				
	5 c.c.	20 c.c.	65 c.c.	95 c.c.	125 c.c.	10 c.c.	25 c.c.	70 c.c.	100 c.c.	130 c.c.
First day.....	.0840	.0702	.0762	.0274	.0129	.0506	.0320	.0828	.0777	.0464
Second day.....	.1357	.1208	.1019	.0494	.0102	.1044	.0766	.1150	.1073	.0624
Third day.....	.1320	.1590	.0810	.0476	.0084	.1263	.1080	.1082	.0896	.0513
Fourth day.....	.1223	.1287	.1346	.0682	.0029	.1082	.1226	.1047	.0996	.1002
Fifth day.....	.0950	.1031	.0858	.0759	.0110	.0765	.0659	.1029	.0814	.0632
Sixth day.....	.0403	.0576	.1000	.0788	.0076	.0963	.0090	.0441	.0723	.0528
Seventh day....	.0623	.0676	.0680	.0730	.0155	.0709	.0122	.0258	.0633	.0480
Total.....	.6516	.6870	.6475	.4203	.0685	.6332	.4263	.5835	.5912	.4243
Saturated with water.....	1–25	1–6	1–2	3–4	Full	1–13	1–5	7–13	3–4	Full
Carbon dioxide formed in per cent of maximum.....	95	100	94	61	10	100	67	92	93	67

The first three quantities of water cause little differences in the production of carbon dioxide in soil No. 1956. With 95 c.c. ($\frac{3}{4}$ per cent. of the saturation capacity of the soil), only about one-half as much carbon dioxide is formed. With 125 c.c. (100 per cent. of saturation), approximately one-ninth as much carbon dioxide is produced. Pouring on the water appears to decrease the production of carbon dioxide to a slight extent.

With soil No. 2378, mixing with 100 c.c. and 130 c.c. water ($\frac{3}{4}$ and 100 per cent. of its saturation capacity), decreased the production of carbon dioxide to about one-fourth, or a little less. When these quantities of water were poured on the soil, the production of carbon dioxide was much greater. The production of carbon dioxide in this soil appears to proceed vigorously even when the soil is saturated with water. It is a peculiar fact that the soils when almost dry oxidized the organic matter very rapidly.

EFFECT OF METHOD OF ADDING WATER.

In this experiment, the two methods of adding water used in the preceding section were tested on several other soils. Five hundred grams soil were mixed with 2.5 grams manure. One mixture was prepared by adding the water upon the surface of the soil, the other by mixing soil and water in a porcelain dish, as described in the previous section. The results are presented in Table 19, and a summary in Table 20. The amount of water used was one-third the saturation capacity of the soil.

TABLE 19—EFFECT OF METHOD OF ADDING WATER ON PRODUCTION OF CARBON DIOXIDE IN GRAMS.

	1956		341		897		1075		1128	
	Mixed	Not Mixed	Mixed	Not Mixed	Mixed	Not Mixed	Mixed	Not Mixed	Mixed	Not Mixed
First day	.0812	.0631	.0092	.0008	.1560	.1540	.0100	.0384	.0291	.0128
Second day	.0872	.1379	.0042	.0144	.1620	.1486	.0798	.0774	.0172	.0155
Third day	.0705	.0763	.0324	.0298	.1462	.1479	.1330	.1005	.0109	.0076
Fourth day	.0605	.0754	.0612	.0410	.1283	.1304	.0790	.1066	.0090	.0112
Fifth day	.0470	.0634	.0928	.0520	.1260	.1356	.0438	.0958	.0112	.0127
Sixth day	.0402	.0536	.0552	.0274	.0902	.0946	.0928	.0772	.0083	.0135
Seventh day	.0043	.0594	.0342	.0571	.0858	.0897	.0123	.0488	.0281	.0194
Eighth day	.0274	.0448	.0458	.0322	.0619	.0668	.0771	.0808	.0337	.0202
Ninth day	.0340	.0398	.0769	.0408	.0547	.0544	.1312	.0662	.0145	.0191
Tenth day	.0248	.0332	.0538	.0286	.0303	.0378	.0600	.0553	.0127	.0180
Eleventh day	.0270	.0329	.0268	.0263	.0335	.0298	.0898	.0506	.0305	.0211
Twelfth day	.0235	.0439	.0302	.0162	.0230	.0221	.0558	.0526	.0154	.0048
Totals	.5276	.7237	.5227	.3666	1.0979	1.1117	.8646	.8502	.2206	.1759

The results of this experiment are not all in the same direction. With soils Nos. 897 and 1075, the method of adding the water had no effect upon the results. Mixing soil and water decreased the production of carbon dioxide in soil No. 1956, and increased it in soils Nos. 341 and 1128.

These results, taken in connection with those discussed in the preceding section, show that the effect of mixing the soil with water depend on the nature of the soil and the amount of water added.

TABLE 20—EFFECT OF MIXING WITH WATER ON PRODUCTION OF CARBON DIOXIDE.

	First Six Days.		Twelve Days.	
	Mixed.	Added On Top.	Mixed.	Added On Top.
1956	.3866	.4697	.5276	.7237
341	.2550	.1654	.5227	.3666
897	.8087	.8111	1.0979	1.1117
1075	.4384	.4959	.8646	.8502
1128	.0857	.0733	.2206	.1759

THE EFFECT OF CARBONATE OF LIME.

This series of experiments was carried out in Erlenmeyer flasks of 500 c.c. capacity. The flasks were provided with 3-hole rubber stoppers, carrying three glass tubes. One tube opened near the top of the flask, and was for withdrawing the air. A second tube reached just to the surface of the soil. Air free from carbon dioxide entered at this tube. A third tube extended to the bottom of the flask. At the end of the experiment, the first tube was connected with a condenser and a carbon dioxide absorption train, and steam free from carbon dioxide was passed through the soil through the tube reaching to the bottom of the flask. The object of this was to expel any carbon dioxide which might be combined with carbonate of lime.

TABLE 21—EFFECT OF CARBONATE OF LIME ON OXIDATION.

	None.	.20 Per cent.	.5 Per cent.	1.0 Per cent.	2.0 Per cent.
1956					
First day	.0199	.0140	.0148	.0170	.0169
Second day	.0191	.0166	.0229	.0202	.0202
Third day	.0244	.0225	.0241	.0247	.0267
Fourth day	.0217	.0213	.0257	.0227	.0237
Fifth day	.0226	.0145	.0219	.0234	.0228
Sixth day	.0231	.0291	.0292	.0211	.0177
Seventh day	.0220	.0171	.0209	.0187	.0227
	.1528	.1351	.1595	.1478	.1507
Eighth day—by boiling out with steam	.0244	.0199	.0176	.0165	.0166
Total for eight days	.1772	.1550	.1771	.1643	.1673
First period three days	.0634	.0531	.0618	.0619	.0638
Second period three days	.0674	.0649	.0768	.0672	.0642
Third period one day	.0220	.0171	.0209	.0187	.0227
Totals	.1528	.1351	.1595	.1478	.1507

The results of the experiment are shown in Table 21. The carbonate of lime has no decided effect upon the oxidation of the organic matter.

This experiment also shows that the soil retains only small quantities of carbon dioxide, under the conditions of our work, even when calcium carbonate is present to retain the carbon dioxide in the form of calcium bicarbonate.

DESCRIPTION OF SOILS.

114. Travis Gravelly Loam; Austin, Travis county; surface soil.

336. Susquehanna Fine Sandy Loam; Caldwell county, three miles N. Lockhart; surface soil.

341. Susquehanna Fine Sandy Loam; Henderson, Rusk county; subsoil.

857. Orangeburg Fine Sandy Loam; 12″-36″; three-fourths mile N. Stockdale, Wilson county.

870. Laredo Fine Sandy Loam; 19″-36″; Webb county, three and one-half miles N. Laredo.

876. Wilson Clay Loam; 10″-36″; Wilson county, five miles S. E. Stockdale.

880. Austin Fine Sandy Loam; 12″-36″; Wilson county, three-fourths mile W. Floresville.

885. Orangeburg Fine Sand; 28″-36″; Robertson county, one mile W. Franklin.

895. Lufkin Fine Sand; 0″-12″; Angelina county, one mile N. Lufkin; F. M. Smith's farm.

897. Norfolk Fine Sand; surface soil; Cherokee county; J. T. Cocke farm, Jacksonville.

914. Lufkin Fine Sandy Loam; 0″-10″; Bastrop county, Bastrop.

937. Orangeburg Fine Sandy Loam; 0″-12″; Wilson county, three-fourths mile N. Stockdale.

938. Austin Fine Sandy Loam; 0″-12″; Wilson county, three-fourths miles W. Floresville.

939. Houston Black Clay; 0″-10″; Delta county.

958. Orangeburg Fine Sandy Loam; surface soil; Cherokee county, Jacksonville.

1067. Susquehanna Fine Sandy Loam; 10″-36″; Bastrop county, two miles N. Bastrop.

1065. Laredo Clay; surface soil; Cameron county, San Benito.

1119. Susquehanna Fine Sand; 0″-8″; Franklin county, one-third mile S. W. Mt. Vernon; J. Patton's field; reddish brown; behaves well when wet; loose and porous when dry; rolling; produces one-third bale cotton, 20 bushels corn.

1128. Houston Clay; 6″-15″; Franklin county; four miles N. Mt. Vernon.

1133. Norfolk Fine Sand; 0″-6″; Franklin county, three and one-half miles S. Mt. Vernon; Ennis Runnel's farm; light brown; loose and open; works well in wet weather; no gravel; produces one-fourth bale cotton, 15 bushels corn.

1135. Norfolk Fine Sandy Loam; 0″-12″; Franklin county, one-half mile E. Mt. Vernon; Mr. Major's orchard; reddish gray; loose and porous when dry; soil retains moisture for some time; rolling; produces one-half bale cotton, 20 bushels corn.

1202. Victoria Clay; 0″-10″; Nueces county, Corpus Christi; dark brown to black, heavy clay.

1290. Norfolk Sand; surface soil; Anderson county; Latimer and Ezell's place.

1809. Soil from College Farm; surface soil; Brazos county, between College and Bryan; sandy soil.

2378. Orangeburg Fine Sandy Loam; Cherokee county; C. D. Jarrett farm, near Dialville; red and sandy; cultivated since 1855.

TABLE 22—COMPOSITION OF SOILS.

	Travis Gravelly Loam.	Susquehanna Fine Sandy Loam.	Susquehanna Fine Sandy Loam.	Susquehanna Fine Sandy Loam.	Laredo Fine Sandy Loam.	Wilson Clay Loam.	Austin Fine Sandy Loam.	Orangeburg Fine Sand.	Lufkin Fine Sand.
	Surface. 114	Surface. 336	Subsoil. 341	Surface. 857	Surface. 870	Subsoil. 876	Subsoil. 880	Subsoil. 885	Surface. 895
Percent:									
Phosphoric Acid	.04	.04	.10	.05	.03	.07	.08	.06	.03
Nitrogen	.13	.10	.04	.05	.06	.10	.03	.63	.06
Potash	.52	.34	.15	.52	.57	.36	.38	.15	.10
Total Potash	1.60	1.00	.....	.56	1.55	.....	.....	.50	.82
Lime	1.47	.70	.07	.30	.54	.41	17.40	.13	.18
Magnesia	.16	.20	.18	.55	.63	1.89	4.66	.19	.23
Alumina and Oxide of Iron	15.06	15.12	16.56	14.33	8.67	18.88	4.59	5.99	1.93
Insoluble and Soluble Silica	67.21	72.39	71.47	74.05	83.39	63.49	46.78	91.00	95.50
Loss on Ignition	7.80	5.20	5.55	4.25	5.87	8.87	10.52	2.08	6.26
Moisture	6.42	5.35	5.37	5.05	3.97	5.18	1.55	.53	.66
Parts Per Million:									
Active Phosphoric Acid	12	7	18	18	10	66	.....	89	28
Active Potash	208	217	167	26	244	18	.....	167	168
Acidity	.....	0	0	200	0	.....	.....	0	300

TABLE 22—COMPOSITION OF SOILS—Continued.

	Norfolk Fine Sand.	Lufkin Fine Sandy Loam.	Orangeburg Fine Sandy. Loam.	Austin Fine Sandy Loam.	Houston Black Clay.	Orangeburg Fine Sandy Loam.	Susquehanna Fine Sandy Loam.	Laredo Clay (probably).	Susquehanna Fine Sand.
	Surface 897	Surface 914	Surface 937	Surface 938	Surface 939	Surface 958	Subsoil 1067	Surface 1075	Surface 1119
Percent:									
Phosphoric Acid	.04	.01	.01	.17	.04	.20	.02	.19	.03
Nitrogen	.03	.05	.03	.09	.13	.13	.06	.20	.04
Potash	.11	.08	.41	.35	.32	.....	.63	.20	.11
Total Potash	.14	.....	.....	.....	.99	.....	.....	.....	.....
Lime	.02	.18	.12	35.40	1.42	.32	.46	8.91	.07
Magnesia	.01	.07	.10	5.05	.89	3.46	.57	1.94	.17
Alumina and Oxide of Iron	1.16	1.37	1.61	2.92	14.00	20.74	14.75	13.55	2.41
Insoluble and Soluble Silica	97.56	95.59	95.40	46.65	67.71	68.56	74.27	51.12	96.01
Loss on Ignition	1.03	1.08	1.00	8.10	8.51	7.36	4.18	13.11	1.05
Moisture	.02	.37	.17	.78	5.45	1.69	4.16	9.12	.34
Parts Per Million:									
Active Phosphoric Acid	63	40	14	420	76	.....	7	132	25
Active Potash	.....	320	270	340	.....	.....	288	.....	220
Acidity	.....	.....	0	0	.....	0	0	0	25.2

TABLE 22—COMPOSITION OF SOILS—Continued.

	Houston Clay.	Norfolk Fine Sand.	Norfolk Fine Sandy Loam.	Victoria Clay.	Norfolk Sand.	Sandy Soil.	Sandy Loam.	Orangeburg Fine Sandy Loam (probably).
	Subsoil 1128	Surface 1133	Surface 1135	Surface 1202	Surface 1290	Surface 1809	Surface 1956	Surface 2378
Percent:								
Phosphoric Acid	.06	.03	.02	.04	.01	.03	.04	.02
Nitrogen	.10	.03	.04	.06	.02	.11	.03	.04
Potash	1.12	.06	.18	.65	.08	.13	.07	.09
Total Potash	.....	.76	.87	.90	.32	.94	1.34	.....
Lime	.45	.60	.07	2.35	.05	.59	.33	.18
Magnesia	.06	.14	.07	1.39	.03	.88	.06	.12
Alumina and Oxide of Iron	18.07	2.36	2.14	13.81	1.31	6.56	1.01	4.10
Insoluble and Soluble Silica	66.89	95.51	95.34	62.86	98.15	84.63	98.07	93.47
Loss on Ignition	7.40	1.96	.87	8.10	.68	.....	.....	.....
Moisture	4.57	.63	.45	7.25	.51	.....	.....	.....
Parts Per Million:								
Active Phosphoric Acid	.....	97	12	192	21	78	75	9
Active Potash	.....	129	216	737	90	228	106	153
Acidity	399	200	0	0	0	0	.....	0

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SUMMARY AND CONCLUSIONS.

1. In a study of the oxidation of organic material by means of the loss on ignition, it was found that the organic matter disappears rapidly during the first three weeks; after that time the loss on ignition is irregular, and the changes could not well be followed.

2. Corn chops, rice hulls, wheat shorts and wheat bran were oxidized 72 to 81 per cent. in 81 weeks, as measured by loss on ignition. Meat tankage and blood were oxidized 47 to 68 per cent. Excrement and bat guano were oxidized 15 to 22 per cent.

3. Subsequent work on oxidation was conducted on soil in percolation jars placed within Witt's filtering jars, and the carbon dioxide produced was absorbed by means of soda lime. The soil under these conditions is probably more porous and oxidized organic matter more readily than the soil under field conditions.

4. Cottonseed meal is rapidly oxidized, about 10 per cent. in one day, and nearly 30 per cent. in four days. In another experiment, 38.8 per cent. of the carbon of cottonseed meal, 10.1 per cent. of the manure, and 8.8 of the corn cobs, were oxidized in the first week.

5. Oxidation decreases rapidly after the first week. With cottonseed meal, the oxidation of each succeeding week was about one-half of the preceding week, until during the fourth week the oxidation became so slow as hardly to be distinguished from the soil carbon. The decrease in oxidation of excrement was less rapid, but still marked. Humic acid was very resistant towards the oxidation processes.

6. The relative powers of soils to oxidize excrement (oxidation capacity) under the conditions of the work here described, varied comparatively little with most of the soils, but was low with three of seventeen soils.

7. There are decided differences in the oxidation of the soil carbon in the different soils. The relative oxidation of the soils tested (based on equal nitrogen) was 130 for three soils containing less than 0.04 per cent. nitrogen, compared with 81 for six soils containing .05 to .099 per cent. nitrogen and 42 for six soils containing over 0.1 per cent. nitrogen. The soils containing the least nitrogen appear to carry their carbon in a more easily oxidized condition.

8. Soils when almost dry oxidized organic matter rapidly. Oxidation in a saturated soil depends upon the character of the soil and the way in which the water is added. The oxidation may be very low or moderate.

9. Carbonate of lime had little or no effect upon oxidation in the soil tested.